PAVVET

Pavement Analysis Via Vehicle Electronic Telemetry

Project Overview and Progress

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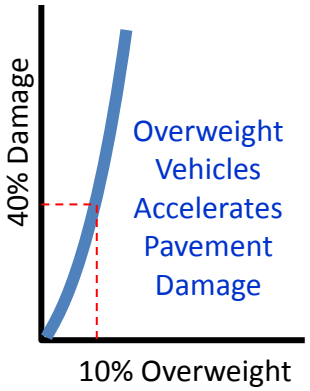
The Problem

- Accelerated Pavement Deterioration
  - Increasing truck payload by only 10% increases pavement damage by 40%
  - National freight traffic will double in 25 years due to GDP growth alone (FHWA Freight Analysis Framework, 2006)
  - Exponential increase of heavy vehicles servicing oil fields
  - Bridge states like ND will support proportionally more truck traffic with expanding international trade
- Rougher roads increases stakeholder costs
  - Slows traffic and promotes congestion where
    - vehicles consume more fuel
    - vehicles emit more greenhouse and toxic gases
    - productivity diminishes (opportunity cost, delayed deliveries)
  - Increases vehicle operating cost
  - Increases damage (risk) for vibration sensitive freight
  - Increases crash risk
- Ride condition monitoring if problematic and expensive
  - Seasonal monitoring could miss worst problems
  - Jurisdictions that cannot afford it do not collect data

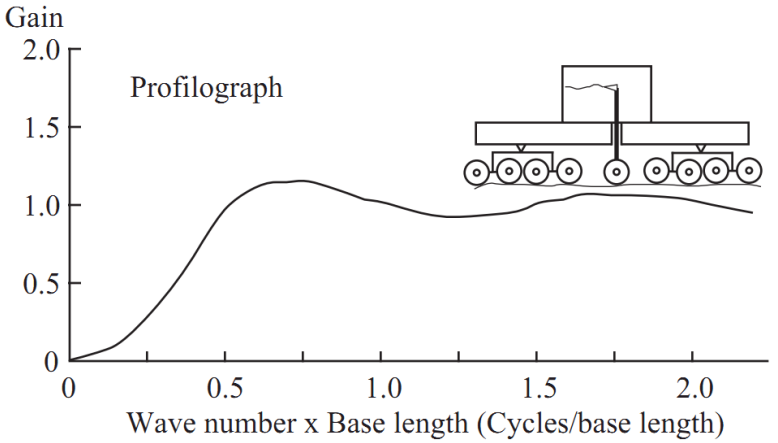


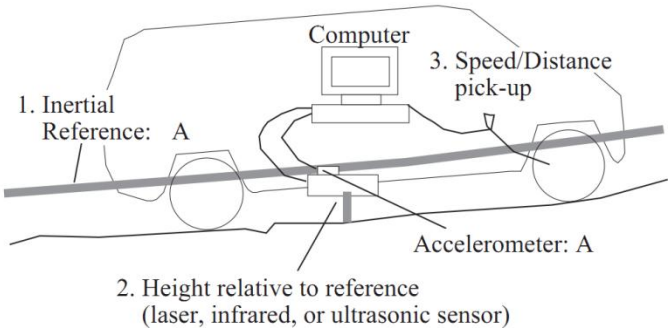
Based on the theory of Equivalent Single Axel Loads

Frequent Monitoring is Expensive

Special Vehicles With Calibrated Sensors

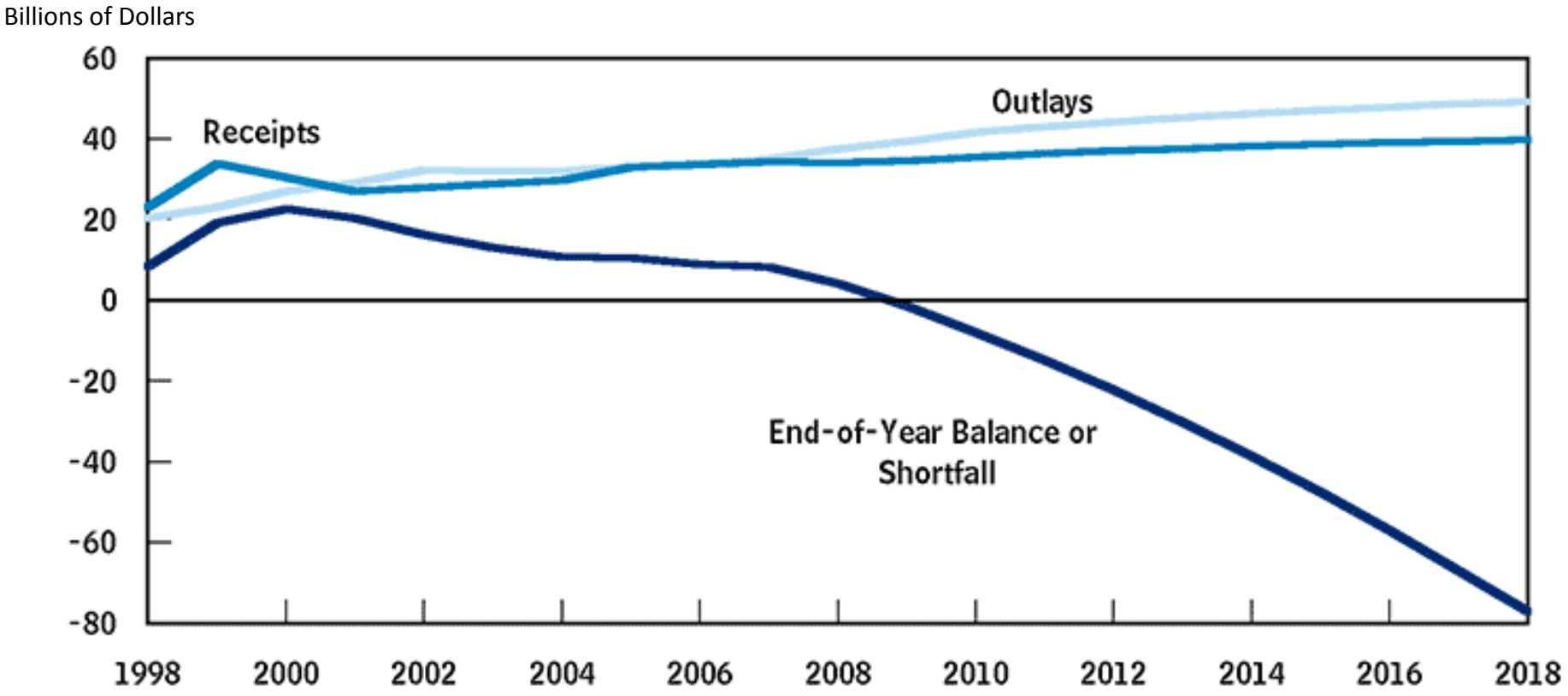
Manual Profilorometers





Visual Inspection

Diminishing Funds for Road Maintenance

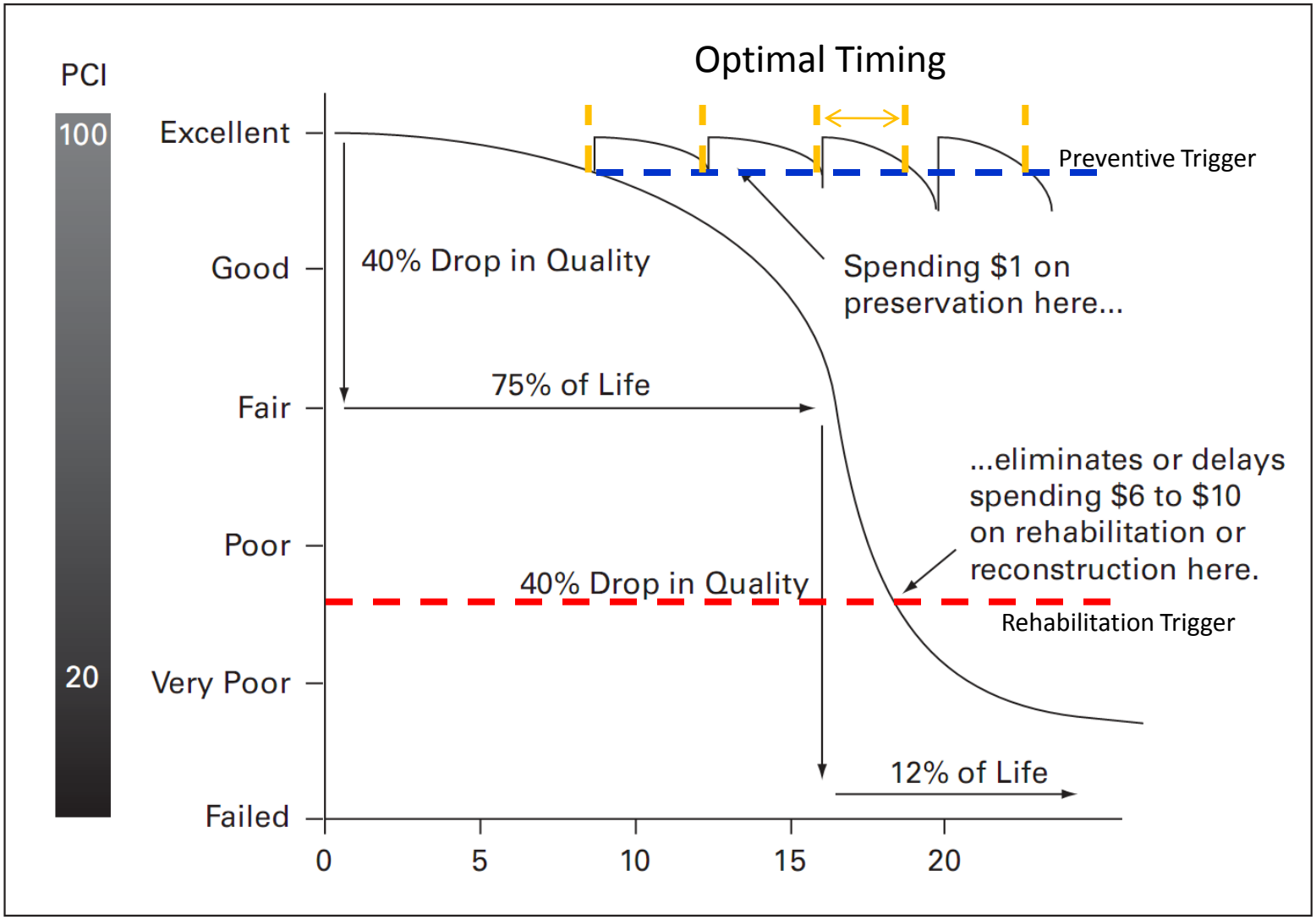


Source: Congressional Budget Office

Note: Actual data are in nominal dollars for 1998 through 2007. Data projections for 2008 to 2018 assume that the Highway Trust Fund's taxes, which are scheduled to expire in 2011, will be reauthorized at current levels. Under current law, the Highway Trust Fund cannot incur negative balances. A negative level is a projected shortfall, reflecting the trust fund's inability to pay obligations out of estimated receipts. Assumptions are based on authorization levels for SAFETEA-LU, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users.

Optimal Timing Minimizes Cost

"Preserve First" vs. "Fix-Worst-First"

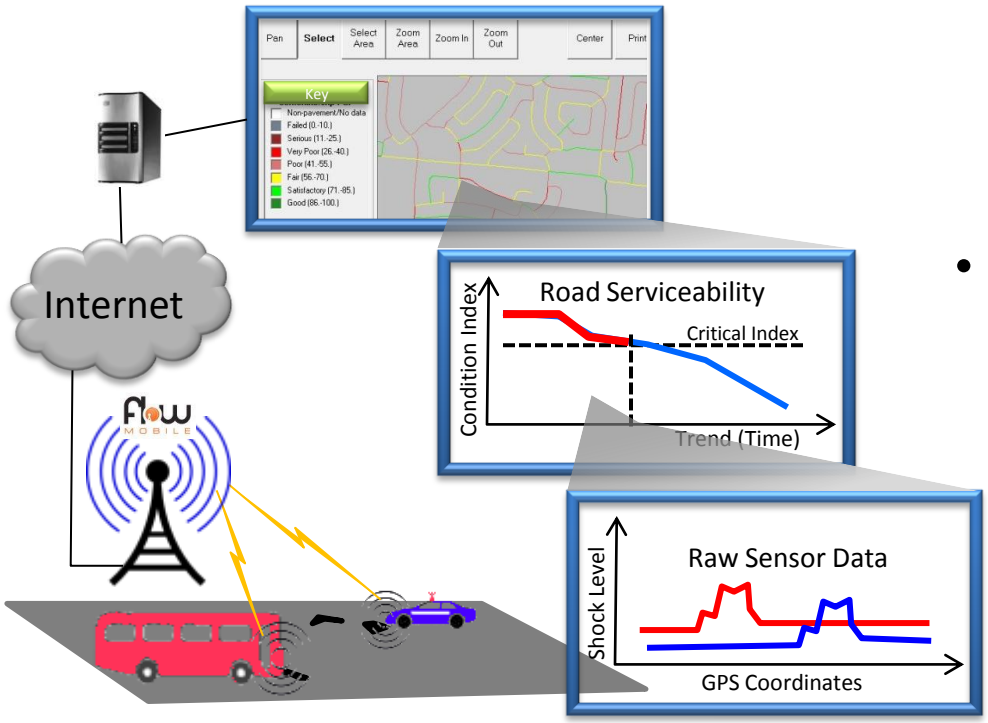


Source: FHWA, Pavement Preservation Compendium II, 2006

The PAVVET Approach

Functional Overview

- On-board vibration and GPS sensors
- Wide area network data connectivity
- Vibration data signal processing
- Web-based host processing



Applications

- Maintenance Optimization
  - Automatic condition monitoring
  - Reduced visual inspection costs
  - Optimum maintenance 2x less expensive than “fix-worst-first”
- Ride Quality Level of Service
  - Roughness classification
  - Pothole detection
  - Obstacle detection
  - Pavement/bridge flaw detection
- Demand Planning
  - Monitor damage caused by heavy vehicles in various industrial regions (e.g. oil, manufacturing, farming)
  - Budget planning and optimization to maximize funding coverage
  - Data input for usage revenue and maintenance cost models

Task Summary and Progress

- Task 1 – Secure project funding
  - NDDOT contract completed
  - Appareo Inc. delivered equipment and software
- Task 2 – Conduct literature search
  - About 50% complete
- Task 3 – Architect a systems solution
  - Approach identified
  - Theoretical framework in development
- Task 4 – Implement the prototype
  - Interfaced with Appareo to determine prototype configuration
  - Equipment mount designed and implemented
  - Operational refinements in progress
- Task 5 – Deploy and evaluate prototype
  - Equipment installed in a vehicle and collecting data via memory card
  - Investigating potential for adding a wireless connection
- Task 6 – Demonstrate proof-of-concept
  - Developing tools for data visualization and analysis
- Task 7 – Complete final project report

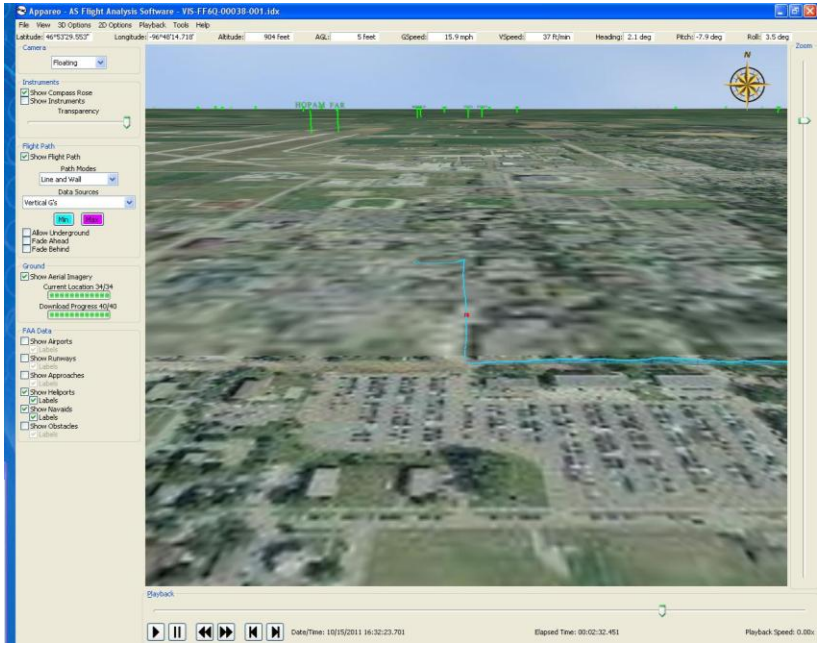
One Evaluation Hardware Installed

- Appareo Vision 1000
  - Images at 4 frames/sec
    - Selectively disable for NDDOT installations
  - Accelerometer x, y, z
  - Ground speed
  - GPS coordinates
- Status
  - Installed in a personal vehicle for initial evaluation
  - Collecting and analyzing data

Software Configured to Capture Data

- Image and sensor response from railroad tracks on Bolley Drive on Campus

- Image Viewer
  - Streaming images
  - Route View (aerial)
- Accelerometer Viewer
  - Speed
  - Vertical G force



Program Staffing

- Principal Investigator (Raj Bridgelall)
  - Solutions architect
  - Theoretical framework development
  - Vision and execution
- Signal Processing Engineer (Hired)[1]
  - MSEE in progress
  - Data management
  - Digital signal processing
- Software Engineer (Hired)[1]
  - BSCS in progress
  - GIS and mapping interfaces
  - Data visualization
- Research Fellow (Mohammad Smadi)
  - Daily activity coordination
  - Vehicle operations and data collection

NDSU
Automatic & Real Time Pavement Condition Monitoring System

Personnel Expense		
Salaries & Wages - Professional	$3,481	
Salaries & Wages - Support Staff	$0	
Salaries & Wages - grad/undergrad students	$16,685	
Fringe Benefits - Professional/Support (31%)	$1,079	
Fringe Benefits - Grad/undergrad students (10%)	$1,669	
Total Personnel Expense		$22,914
Operating Expense		
Travel - Domestic	$0	
Travel - Foreign		
Utilities		
Communications	$0	
Insurance		
Data Processing *(Software Purchases)*	$0	
Rents & Leases		
Office Expense		
Repair/Maintenance		
Research /Instructional Supplies	$0	
Fees		
Subcontracts		
Other *(Training)*	$0	
Expendable Equipment		
Total Operating Expense		$0
Equipment		
Major Equipment		$0
Total Direct Costs		$22,914
Facilities & Administrative Costs (Indirect Cost) (10%)		$2,291
Total Cost		$25,205

[1] NDDOT primarily funds the two students. SMARTSe funds the remaining activities.

Summary and Conclusions

- Significant progress
  - Matching support received from Appareo Inc. (1 unit)
  - Research assistants hired
  - Essential hardware and software installed
  - Initial data collection and viewing
- Next Steps
  - Theoretical framework development
  - Extensive data capture and analysis
  - Advanced signal processing
  - Model development for Road Impact Factor (RIF)
  - Model validation with newly collected data
  - Technical presentation to NDDOT
  - Demonstration of initial progress to NDDOT